Do *Philomycus carolinianus* (Gastropoda: Philomycidae) prefer to congregate?

Timothy A. Pearce
Katherine A. Porter
Section of Mollusks
Carnegie Museum of Natural History
Pittsburgh, PA 15213 USA
PearceT@CarnegieMNH.org

ABSTRACT

Field observations of land slugs *Philomycus carolinianus* (Bosc, 1802) together at shelters led us to ask whether they were attracted to conspecifics versus attracted to a limited resource (e.g., shelter). Our laboratory experiment offered three shelters to three slugs in each replicate, with the expectation that slugs would occur together under a single shelter if they preferred to be with conspecifics, while slugs would occur singly under each shelter if they avoided conspecifics. We found that slugs chose shelters regardless of the presence of conspecifics, suggesting that their occurrence together in nature is due to the sharing of limited shelter resources.

Additional key words: land slugs, shelter, limited resource

INTRODUCTION

Animals congregate for many reasons. In some cases, they benefit from the presence of others. In other cases, they occur together in an area because a resource is present there. Explanations for congregation behavior in terrestrial mollusks include prevention of water loss (Dundee et al., 1975; Cook, 1981; Waite, 1988) and escape from ground-level heat (Cook, 2001).

In nature, gastropods are commonly associated with woody debris, and can be found congregated in areas with large amounts of such debris (Kappes et al., 2009). Individuals of species of slugs in the genus *Philomycus* Rafinesque, 1820 are sometimes seen in close proximity to each other, especially near coarse woody debris. In some cases, these slugs are found in physical contact with each other (a phenomenon known as huddling). However, *Philomycus* individuals do not always exhibit huddling in the wild, and the presence of multiple slugs in close proximity is yet to be explained. Two possible explanations are that individuals of *Philomycus* species are gregarious (prefer to associate with each other) and that they tend to congregate at the locations of limiting resources, regardless of the presence of other slugs.

Huddling and congregation are not unique to *Philomycus* species. Örstan (2007) noted huddling by individuals of the same and of different species of slugs, but we do not know whether the same mechanisms are acting in inter- and intra-specific huddles. In addition, although we now have better understanding of the systematics of Philomycidae (Fairbanks, 1986; 1989; 1990; 1993; 1998; Tsai et al., 2005; Tsai and Wu, 2008), we still know relatively little about their biology. In this note, we examine congregation and huddling behavior among individuals of a single species, the eastern North American slug *Philomycus carolinianus* (Bosc, 1802).

MATERIALS AND METHODS

Slugs were wild-caught in spring 2009 from the Patuxent National Wildlife Refuge, Prince George's County, Maryland (39°03′ N, 76°49′ W). The slugs were used in another experiment over the summer, then provided to us for this study, which was conducted from 27 October to 21 November 2009. Voucher specimens, preserved in 80% EtOH within a day post mortem, are deposited at Carnegie Museum of Natural History (CM104587).

We prepared three arenas. Each was 44 × 28 × 22.5 cm high. The arenas were corrugated cardboard boxes, each lined with a plastic bag and covered with a 1.4 mm mesh screen. To maintain humidity in the arenas, each screen was covered with a stack of 12 moistened paper towels. Each paper towel had a surface area of 276 cm^2. Each arena floor was covered with soil approximately 1 cm deep. In each arena, we placed three bark shelters measuring approximately 12 cm long, 10 cm wide, and 1.5 cm thick. Each arena also contained a water dish and a food dish that contained fish food flakes and mushroom slices. The amounts of food and water provided were ample for the number of slugs in each arena, ensuring that neither food nor moisture was limiting. Shelter was the limiting factor; other than the bark, food dish, and water dish, the arena was devoid of objects that could function as shelters.

We placed three mature slugs in each arena. For each replicate, we observed slug positions once daily for six days. Observations were made during the daytime when slugs would more likely be resting under shelters. Time of day when observations were made ranged from 7:42–21:44 with a mean of 12:55 (95%, CI 9:00–16:50). Because we had a limited number of slugs, we re-used slugs in subsequent trials to maximize the number of replicates. The assigning of individuals to arenas was not strictly random. Rather, with the exception of 2 individuals in the last trial, the slugs were grouped in a manner ensuring that the individuals together in one trial would not be together in a subsequent trial.

We compared the observed slug positions with a null model, which assumed a random distribution of slugs under the shelters. We generated the null model by determining the 18 possible arrangements of three slugs under three shelters. This null model predicts nine instances of singletons (slugs alone under shelters), six instances of pairs (two slugs under the same shelter), and three instances of triplets (three slugs under the same shelter). Triplets would be expected to be more common if slugs are gregarious and less common if they prefer to be solitary. We used a chi-square test to determine the statistical significance of the observations.

RESULTS AND DISCUSSION

Table 1 shows the observed and expected numbers of shelters with different numbers of slugs. With eight replicates (a total of 83 observations), we observed 46 instances of slugs alone under shelters, 31 instances of two slugs under the same shelter, and six instances of three slugs under the same shelter. We discarded 18 observations in which at least one slug was not under a shelter or in which a slug was using the food or water dish as a shelter. We also discarded two replicates in which one of the slugs died. The observed and expected values are not significantly different from random (χ^2 = 5.33, 2 degrees of freedom, $0.1>P>0.05$).

This result suggests that slugs choose shelters randomly, without regard to whether another slug is present. Of particular interest is the observed trend for fewer triplets than predicted by the random model (6 vs. 13.8). Although this trend is not statistically significant, it does suggest that these slugs are not gregarious.

Table 1. Number of shelters having 1, 2, or 3 slugs underneath. χ^2 analysis indicates the slugs were behaving randomly ($0.1>P>0.05$).

Number of slugs in shelter	Observed	Expected	χ^2_p
1	46	41.5	0.49
2	31	27.7	0.40
3	6	13.8	4.44
Totals	**83**	**83**	**5.33**

Because these slugs appear to assort randomly, congregations of slugs found in nature may indicate the presence of a scarce resource (e.g., shelter) in that particular location. Therefore, observations of slug huddling could be used as evidence for resource scarcity. For example, some land slugs appear to cluster to conserve moisture (Dundee et al., 1975; Cook, 1981; Waite, 1988; although see Welsford et al., 1990). In this experiment, food and moisture were non-limiting. A repetition of the experiment in which moisture, rather than shelter, was the limiting factor might allow us to study whether individuals of *Philomycus carolinianus* do huddle to conserve moisture. Investigations in which other resources were limiting could also address whether huddling occurs due to the scarcity of other resources.

All of the slugs used in this investigation were mature. An investigation of the effects of age on congregation behavior could provide additional data on the behavior of *Philomycus* species. Studies involving species other than *P. carolinianus* could determine whether other species show similar behaviors.

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